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Investigations of a Turbulent Jet in a Crossflow

Several aspects of the flow field downstream of a jet directed at right angles into a crossflow were studied experimentally. Single jets, both heated and unheated, were injected into a uniform, ambient temperature crossflow. Ratios of jet momentum to crossflow momentum ranged from 16 to 64. Longitudinal and transverse distributions of velocity, temperature, and turbulence intensity were measured at distances up to 70 nozzle diameters downstream from the injection plane.

In recent years, considerable attention has been given to the various aspects of jets issuing into a subsonic crossflow since this is the basic configuration in numerous situations of significant concern, such as:

1. Cooling of hot gas streams by the injection of jets of cool gas, e.g., cooling gas turbine combustor exit gases by injecting cooler air through holes in the liner wall;
2. The aerodynamic effects of propulsion system jet flows on the performance of STOL and VTOL aircraft;
3. The distribution of contaminants discharged from a chimney into the wind; and
4. The distribution of contaminants discharged into flowing water.

This investigation was motivated by the gas turbine combustor gas cooling problem. Although multiple jets are used in actual applications, the injection of a single jet into a semi-infinite crossflow is a basic component of the system. The results obtained from this study provide basic information not only for the combustor cooling problem, but also for many other applications.

Detailed aspects of a jet injected into a crossflow of the same temperature were investigated first to better understand the mixing process. Distribution of velocity, pressure, and turbulence intensity were measured at several sections in the jet. The data revealed a complex structure of the jet, strongly influenced by a pair of

counter-rotating eddies which are formed behind the jet. Therefore, the rotational velocity field was also investigated in detail.

The mixing of the two flows at different temperatures was investigated by heating the jet above the temperature of the crossflow. Although the buoyancy force acts in opposite directions in heated and cooled jets, this effect does not significantly alter the general flow characteristics. Lateral distribution of temperature at several sections of the jet and longitudinal distribution of temperature along the centerline of the jet were measured in detail to study the mixing of the two flows.

These experiments showed that for both heated and unheated jets, velocity trajectory depends solely on the ratio of jet momentum to crossflow momentum. Jet temperature trajectory, defined by the locus of the maximum temperature difference in the plane of symmetry, was found to be mainly dependent on the momentum ratio, with a weak dependence on density ratio indicated. The twin vortex motion was found to grow stronger with increasing momentum ratio; in heated jets the vortex motion is also influenced by the density ratio. The vortex activity attains its peak in the region where the jet centerline has large curvature and decays rather slowly thereafter. The higher entrainment rate of a jet in a crossflow as compared to a free jet is largely due to the normal component of crossflow velocity.

Notes:

1. The following documentation may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price \$3.00
(or microfiche \$0.95)

Reference: NASA CR-72893 (N71-29896), Experiments on a Turbulent Jet in a Cross Flow

(continued overleaf)

2. Technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
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Patent status:

No patent action is contemplated by NASA.

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